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Non-linear Dynamic Analysis of Precast Concrete Girder Bridge

Prajapati Rahul[1], Megha Thomas[2]
[1]P.G. Student (M-Tech - Structures), Parul Institute of Engineering & Technology, Limda- 391760, Gujarat, India
rahulprajapati177@gmail.com[1]
[2]Associate Professor, Parul Institute of Engineering & Technology, Limda- 391760, Gujarat, India
meghathomas77@gmail.com[2]

Abstract—
For earthquake resistant design, performance Based Design (PBD) is a modern approach. It is an attempt to evaluate the performance of structure under unexpected seismic events. PBD is the extension of limit-state design to cover the complex range of issues such as excessive displacement, rotation, damages, functionality etc. The PBD can be performed on new as well as existing bridges. The performance of such bridges in the event of earthquake can be evaluated using predictive analysis.

Keywords—Precast concrete, Bridge, Finite Element Method,R.C.C. Beidge.

I. Introduction

Structures made in Precast concrete is increasing in India. The special interest of developing any structure is to be done using commonly used construction materials, such as cast-in-place concrete. If the structure is not properly designed when the Earthquake is accrue especially in high seismic regions the structure is damage. Precast technology offers benefits such as reduce construction period, better quality control, cleaner and safer construction sites and others. Precast concrete means concrete which has been prepared for casting and the concrete either is statically reinforced or prestressed. Precast concrete structure refers to the combination of precast concrete elements and the structure is able to sustain vertical and horizontal loads or even dynamic loads.

Good and efficient transportation system is one of the important systems of networking for any nation. Bridges are important components within the transportation systems. The road bridges are designed in our country as per IRC codes, where working stress method is used.The response reduction factor is one of the important factor in determination of design seismic force, which is mainly decided based on amount of ductility introduced in the structure. The bridges are generally placed in two categories: Ordinary and Important. Considering the importance of bridges, it is essential to adequately design new bridges and assess the response of existing bridges in areas subjected to earthquake hazards. The extensive damage of highway bridges in the 1989 Loma Prieta, 1994 Northridge and 1995 Hyogo-ken Nanbu earthquakes together with the research, triggered as a consequence of the recent earthquakes have led to significant advance in bridge seismic design and retrofitting. For this the traditional seismic coefficient method is being replaced with the ductility design method, which is based on nonlinear analysis of structure.

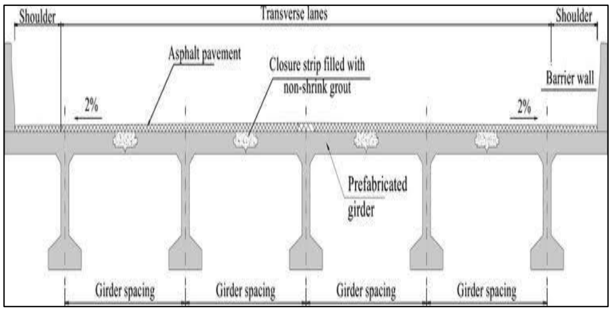

Fig.1 Cross Section of Precast Concrete Girder Bridge

II. Non Linear Static Analysis

In push over analysis of bridge, computer model of bridge is subjected to lateral load of certain shape. (Parabolic, inverted, triangular or uniform). The intensity of lateral loads is slowly increased and sequence of cracks, yielding, plastic hinge formations and failure of various structural components is recorded. Pushover analysis gives us an idea about underperforming points in structure for seismic performance evaluation. Performance point is where the seismic capacity and seismic demand curves meet. If performance point exists and damage state at point is acceptable, we have a bridge that satisfies pushover criteria.

III. Modelling and Analysis

The analysis of bridge can be done using a Grillage analogy and finite element method. Grillage analogy method is simple method and easy to use, in the grillage method the object is discretized in grid of inter connecting beam. Grillage method take less time and not so complicated as FEM. On the other hand FEM,in the FEM the object is discretized in grid of inter connecting plates. Analysis of the object in FEM takes time and required more work but it give more accurate result. For the analysis finite element based software CsiBridge is using and the analysis is on the single span concrete I-girder bridge.

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IV. SPECIFICATIONS CONSIDERD IN BRIDGE DESIGN

Table 1: General data

General Data	
Length of bridge	35 m, 40 m, 45 m
Each Lane width	3.5 m
No. of Lane	4
Total Width	15.2 m
Composite Deck	0.2 m
Concrete Grade	M 40
Grade of steel	HYSD Fe 415
Roadway Width	14 m
Vehicle class	IRC AA Wheel load

➢ Precast girders:

Concrete strength at transfer fci = 0.75fck
= 0.75×40
= 30MPA

Concrete strength at 28 days fc = 40 MPA
Concrete unit weight = 24 KN/M

➢ Pre-Stressing Strands:

12.7 dia. seven wire low relaxation strands
Area of strands = 98.71 mm2
No of strands in one cable = 15
No of cable = 6
Ultimate strength fpu = 1860 Mpa
Yield strength = 0.9 fpu
= 0.9×1860
= 1674 Mpa

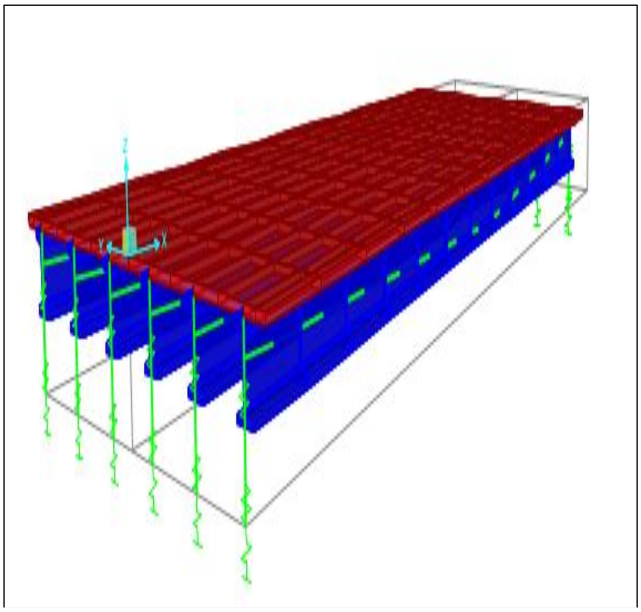

Fig. 2: Side View of Bridge

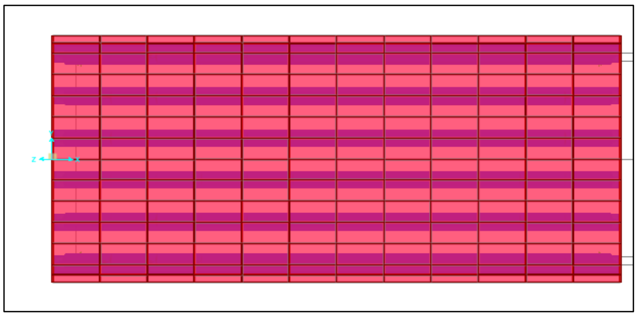

Fig. 3: Top View of bridge

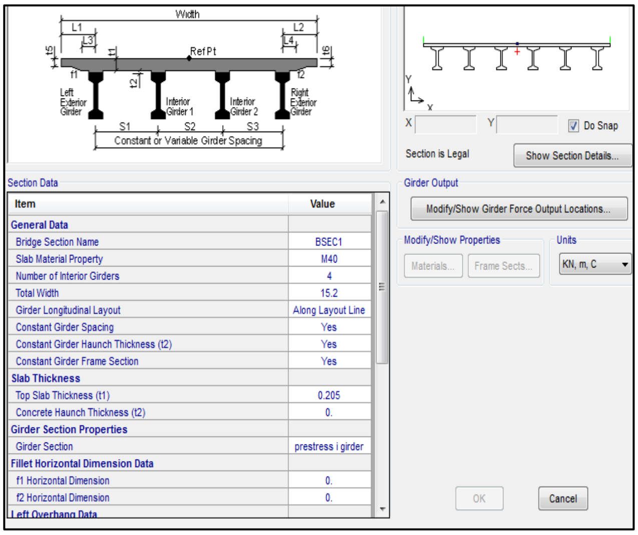

Fig. 4: Bridge Cross Section Data

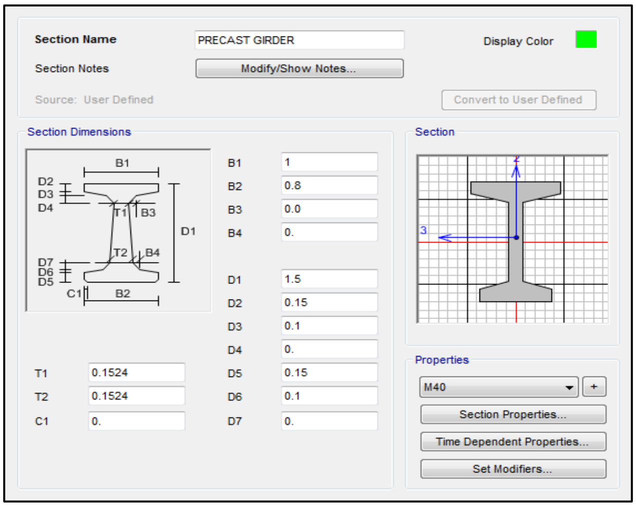

Fig. 6: Precast I Girder Data

Table 2: Shear Vertical at different girders

No.	Shear Vertical(V2)	Span 35 m	Span 40 m	Span 45 m
1	Left Ext. Girder	461.44	529.82	597.37
		-461.35	-531.07	-599.06
2	Int. Girder 1	464.13	530.92	597.55

		-463.22	-529.38	-595.09
3	Int. Girder 2	466.46	532.88	598.97
		-469.41	-533.17	-598.23
4	Int. Girder 3	466.46	532.88	598.97
		-469.41	-533.17	-598.23
5	Int. Girder 4	464.13	530.92	597.23
		-463.22	-529.38	-595.09
6	Right Ext. Girder	461.44	529.82	597.37
		-461.35	-531.07	-599.06

Table 3: Moment about Horizontal axis at different girders

No.	Moment Horizontal	Span 35 m	Span 40 m	Span 45 m
1	Left Ext. Girder	3663	4711	6075
		-10.01	-15.97	-24.85
2	Int. Girder 1	3765	4834	6223
		-8.81	-8.21	-9.26
3	Int. Girder 2	3781	4847	6232
		-28.72	-8.46	-9.48
4	Int. Girder 3	3781	4847	6232
		-28.72	-8.46	-9.48
5	Int. Girder 4	3765	4834	6223
		-8.81	-8.21	-9.26
6	Right Ext. Girder	3663	4711	6075
		-10.01	-15.97	-24.85

Table 4: Torsion at different girders

No.	Torsion	Span 35 m	Span 40 m	Span 45 m
1	Left Ext. Girder	21.63	25.01	30.49
		-21.84	-25.85	-31.93
2	Int. Girder 1	12.40	14.89	18.29
		-12.39	-15.72	-20.24
3	Int. Girder 2	3.95	4.74	5.94
		-3.82	-4.82	-6.46
4	Int. Girder 3	3.82	4.82	6.46
		-3.95	-4.74	-5.94
5	Int. Girder 4	12.39	15.72	20.24
		-12.40	-14.89	-18.29
6	Right Ext. Girder	21.84	25.85	31.93
		-21.63	-25.01	-30.49

Table 5: Vehicle live load on Bridge

No.	Forces	Span 35 m	Span 40 m	Span 45 m
1	Axial Force	1090.25	1311.61	2098.69
		108.40	91.01	122.90
2	Shear Vertical	1798.71	2015.83	2435.76
		653.59	632.84	678.78
3	Torsion	1.487E-06	9.531E-07	7.460E-07
		6.711E-06	4.239E-07	3.167E-07
4	Moment Horizontal	19608.12	17046.02	23905.07
		28.04	19.97	30.99
5	Displacement	0.0208	0.0275	0.0575
		5.556E-09	5.423E-09	7.872E-09
6	Longitudinal stress	2126.68	2134.38	3448.21
		399.70	346.26	354.87

V. Conclusion

1. In the Precast bridge left girder and right girder of bridge the difference in magnitude of moment, shear and torsion of span 35 m, 40 m and 45 m is larger as compared to the interior girder.
2. When we compare R.C.C. and Precast Bridge we get higher Dead load, bending moment, torsion in interior girders & exterior girders of R.C.C. Bridge.
3. As we increase the span the live load shear force, bending moment, torsion, Displacement etc. values for all the girders are increase.
4. In Precast bridge with span 35 m & with span 40 m, the value of Shear vertical (V2) is almost same on entire bridge but the Shear horizontal (V3) over the entire span is different and also in the exterior girder the shear horizontal(V3) is 37% more than that in the interior girder.

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